NASA Contractor Report 198268

Piloted Parameter Identification Flight Test Maneuvers for Closed Loop Modeling of the F-18 High Alpha Research Vehicle (HARV)

E. A. Morelli
Lockheed Martin Engineering & Sciences Company
Hampton, Virginia

Contract NAS1-19000

May 1996

National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23681-0001

Table of Contents

Abstract ii

Nomenclature iii

I. Introduction 1

II. Maneuver Descriptions 2

III. Acknowledgments 4

IV. References 4

V. Input Specification Tables 5

VI. Control Time Histories 17

Abstract

Flight test maneuvers are specified for the F-18 High Alpha Research Vehicle (HARV). The maneuvers were designed for closed loop parameter identification purposes, specifically for longitudinal and lateral linear model parameter estimation at 5, 20, 30, 45, and 60 degrees angle of attack, using the NASA 1A control law. Each maneuver is to be realized by the pilot applying square wave inputs to specific pilot station controls. Maneuver descriptions and complete specifications of the time / amplitude points defining each input are included, along with plots of the input time histories.

Nomenclature

h	altitude, feet
t	time, seconds
V	airspeed, feet/second
α	angle of attack, degrees
η_a	lateral stick deflection in inches, positive for right stick
η_e	longitudinal stick deflection in inches, positive for aft deflection from neutral
η_r	rudder pedal force in pounds, positive for right rudder
τ	time constant, seconds

subscripts

o	nominal or trim value

I. Introduction

The F-18 High Alpha Research Vehicle (HARV) is a highly instrumented research aircraft used in the NASA High Alpha Technology Program[1]. Objectives for this program include validating advanced control system design techniques in flight.

In this work, the technique described in references [2] and [3] was used to design flight test maneuvers consisting of optimal closed loop square wave inputs. These square wave inputs are to be applied by the pilot. The optimal input design technique uses dynamic programming to compute globally optimal square wave inputs for model parameter estimation experiments, based on *a priori* dynamic models. Previous flight test results[4] demonstrated that pilot implementations of such optimal square wave inputs produce superior parameter estimation results compared to conventional inputs. Linear *a priori* dynamic models for the optimal input designs were obtained from an F-18 HARV nonlinear simulation[5]. The maneuvers were designed specifically to collect flight data with maximum information content for dynamic modeling purposes.

Specific objectives addressed by the maneuvers specified in this document are:

1. Identify closed loop longitudinal and lateral linear dynamic models for validation of the control law design methods implemented by the NASA 1A control law.
2. Identify closed loop longitudinal and lateral linear models for comparison and correlation with military specifications for flying qualities of piloted aircraft, pilot comments and handling qualities ratings.
3. Update and verify existing aerodynamic models.

The purpose of this report is to document the specifications for the maneuvers designed to achieve the above objectives.

II. Maneuver Descriptions

There are ten (10) optimal square wave input maneuvers described in this report. The maneuvers can be divided into two groups:

1. Five (5) maneuvers for longitudinal closed loop model identification.
2. Five (5) maneuvers for lateral-directional closed loop model identification.

All maneuvers are to be flown using the NASA 1A control law[6]. Control definitions and sign conventions are given above in the **Nomenclature** section. Detailed descriptions of the maneuvers in each group appear below, with numbering corresponding to that given above.

1. This group of five maneuvers is for identifying closed loop longitudinal dynamic models and for control law design validation. Initial flight conditions are trim angle of attack 5, 20, 30, 45, and 60 degrees and approximately 25,000 feet altitude, with the NASA 1A control law. These maneuvers involve pure longitudinal stick deflection by the pilot.

Optimal longitudinal stick input specifications for $\alpha = 5, 20, 30, 45$ and 60 degrees are given in Tables 1–5, respectively. Each input specification consists of the initial flight condition for the maneuver, followed by a tabulation of the time / amplitude points for the input. Figures 1–5 show time histories for the optimal longitudinal stick inputs at $\alpha = 5, 20, 30, 45$ and 60 degrees, respectively. Pilot station controls for the initial steady flight condition are defined as zero for the inputs shown in the figures. The inputs included a rate limit of 12 inches per second and a first order lag with time constant $\tau = 0.05$ seconds for the longitudinal stick input. These modifications to the square wave input were incorporated in the input design optimization, and were included to model human pilot capabilities. Figures 1–5 show the effects of the first order lag and the rate limiting. The data in Tables 1–5 describe pure square wave inputs. The pilot should attempt to produce the sharp-edged square waves specified in the tables, not the waveforms shown in the figures, which include lag and rate limiting representative of human pilot capabilities. The amplitude of the longitudinal stick deflection is $\pm$ 1.0 inch for all maneuvers in this group. The inputs should be sharp-edged, well-timed, and as close as possible to the target amplitudes. The maneuvers were designed so that each square wave pulse was an integral number of 0.4 second pulses. This was done to accommodate human pilot capability and to facilitate accurate timing of the square wave inputs. The input design optimization included all these practical constraints.

Each maneuver in this group is to be flown two (2) times, for a total of ten (10) runs. Each run should be preceded by at least two seconds of steady trimmed flight, and followed by at least two seconds of free response before the pilot takes action to control the aircraft. The duration of each maneuver is 12 seconds. Estimated flight time for this set of maneuvers (including repeats) is approximately 30 minutes.

2. This group of five maneuvers is for identifying closed loop lateral-directional dynamic models and for control law design validation. Initial flight conditions are trim angle of attack 5, 20, 30, 45, and 60 degrees and approximately 25,000 feet altitude, with the NASA 1A control law. These maneuvers involve sequential rudder pedal and lateral stick deflection by the pilot.

Optimal rudder pedal and lateral stick input specifications for $\alpha = 5$, 20, 30, 45 and 60 degrees are given in Tables 6–10, respectively. Each input specification consists of the initial flight condition for the maneuver, followed by a tabulation of the time / amplitude points for the inputs. Figures 6–10 show time histories for the optimal rudder pedal and lateral stick inputs at $\alpha = 5$, 20, 30, 45 and 60 degrees, respectively. Pilot station controls for the initial steady flight condition are defined as zero for the inputs shown in the figures. The inputs included a rate limit of 4 inches per second on the rudder pedal input and 12 inches per second on the lateral stick input, and a first order lag with time constant $\tau = 0.05$ on both rudder pedal and lateral stick. These modifications to the square wave input were incorporated in the input design optimization, and were included to model human pilot capabilities. Figures 6–10 show the effects of the first order lag and the rate limiting. The data in Tables 6–10 describe pure square wave inputs. The pilot should attempt to produce the sharp-edged square waves specified in the tables, not the waveforms shown in the figures, which include the lag and rate limiting representative of human pilot capabilities. The amplitudes of the rudder pedal and lateral stick deflections are ± 100 pounds and ± 1.5 inches, respectively, for all maneuvers in this group. The inputs should be sharp-edged, well-timed, and as close as possible to the target amplitudes. The maneuvers were designed so that each square wave pulse was an integral number of 0.5 second pulses, in order to accommodate human pilot capability and to facilitate accurate timing of the square wave inputs. Each maneuver in this group consists of a period of pure rudder pedal deflection, followed by one second of neutral controls, followed by a period of pure lateral stick deflection. Therefore, only one pilot input must be moved at any time, and one second is allowed to switch from rudder pedal deflection to lateral stick deflection. Informal fixed-base simulator studies indicated that this arrangement helped the pilot accurately realize the desired square wave input. The input design optimization included all these practical constraints.

Each maneuver in this group is to be flown two (2) times, for a total of ten (10) runs. Each run should be preceded by at least two seconds of steady trimmed flight, and followed by at least two seconds of free response before the pilot takes action to control the aircraft. The duration of each maneuver is 16 seconds, and consists of 8 seconds of pure rudder pedal input followed by 8 seconds of pure lateral stick input. Estimated flight time for this set of maneuvers (including repeats) is approximately 30 minutes.

III. Acknowledgments

This research was conducted at the NASA Langley Research Center under NASA contract NAS1-19000.

IV. References

1. Gilbert, W.P. and Gatlin, D.H. "Review of the NASA High-Alpha Technology Program", NASA CP 3149, Volume I, Part I, High Angle-of-Attack Technology Conference, NASA Langley Research Center, Hampton, Virginia. October 30 - November 1, 1990, pp. 23-59.
2. Morelli, E. A. and Klein, V. "Optimal Input Design for Aircraft Parameter Estimation using Dynamic Programming Principles", AIAA paper 90-2801, Atmospheric Flight Mechanics Conference, Portland, Oregon. August 1990.
3. Morelli, E. A. "Practical Input Optimization for Aircraft Parameter Estimation Experiments", NASA CR 191462. May 1993.
4. Morelli, E.A. "Flight Test Validation of Optimal Input Design using Pilot Implementation", IFAC paper IFAC-559, 10th IFAC Symposium on System Identification, Copenhagen, Denmark. July 1994.
5. Messina, M.D. et al. "F/A-18 High Angle-of-Attack Research Vehicle Simulation Modifications to Assist the Design of Advanced Control Laws", NASA TM 110216, NASA Langley Research Center, Hampton, Virginia. 1996.
6. HARV Control Law Design Team. "Design Specification for a Thrust-Vectoring, Actuated-Nose-Strake Flight Control Law for the High-Alpha Research Vehicle", NASA TM 110217, NASA Langley Research Center, Hampton, Virginia. 1996.

V. Input Specification Tables

LONGITUDINAL CLOSED LOOP OPTIMAL INPUT MANEUVERS

F-18 HARV using the NASA 1A Control Law

5 α OPTIMAL LONGITUDINAL STICK MANEUVER

Initial Conditions

$\alpha_o = 5°$

$V_o = 370$ knots $\quad h_o = 25{,}000$ feet

$|\text{OBES } \eta_e|_{max} = 1.0$ inch

Table 1

(Figure 1)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
0.00	0.0
0.02	1.0
0.40	1.0
0.42	–1.0
1.20	–1.0
1.22	0.0
2.00	0.0
2.02	–1.0
2.80	–1.0
2.82	1.0
3.60	1.0
3.62	–1.0
4.40	–1.0
4.42	1.0
5.20	1.0
5.22	0.0
5.60	0.0
5.62	1.0
6.00	1.0
6.02	0.0
6.40	0.0

(cont.)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
6.42	–1.0
6.80	–1.0
6.82	1.0
7.60	1.0
7.62	–1.0
8.40	–1.0
8.42	1.0
9.20	1.0
9.22	–1.0
10.00	–1.0
10.02	1.0
10.80	1.0
10.82	–1.0
11.60	–1.0
11.62	0.0
12.00	0.0

20 α OPTIMAL LONGITUDINAL STICK MANEUVER

Initial Conditions

$\alpha_o = 20°$

V_o = 198 knots h_o = 25,000 feet

$|\text{OBES } \eta_e|_{max}$ = 1.0 inch

Table 2

(Figure 2)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
0.00	0.0
0.02	–1.0
0.40	–1.0
0.42	0.0
1.20	0.0
1.22	–1.0
1.60	–1.0
1.62	0.0
2.00	0.0
2.02	1.0
2.40	1.0
2.42	0.0
3.20	0.0
3.22	–1.0
3.60	–1.0
3.62	1.0
4.40	1.0
4.42	–1.0
5.20	–1.0
5.22	1.0
6.00	1.0

(cont.)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
6.02	–1.0
6.80	–1.0
6.82	1.0
7.60	1.0
7.62	–1.0
8.40	–1.0
8.42	1.0
8.80	1.0
8.82	–1.0
9.20	–1.0
9.22	0.0
9.60	0.0
9.62	1.0
10.00	1.0
10.02	0.0
10.40	0.0
10.42	–1.0
10.80	–1.0
10.82	0.0
12.00	0.0

30 α OPTIMAL LONGITUDINAL STICK MANEUVER

Initial Conditions

$\alpha_o = 30°$

V_o = 167 knots h_o = 25,000 feet

$|\text{OBES } \eta_e|_{max}$ = 1.0 inch

Table 3

(Figure 3)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
0.00	0.0
0.02	1.0
0.40	1.0
0.42	0.0
0.80	0.0
0.82	1.0
1.20	1.0
1.22	0.0
1.60	0.0
1.62	−1.0
2.00	−1.0
2.02	1.0
2.40	1.0
2.42	−1.0
3.20	−1.0
3.22	0.0
3.60	0.0
3.62	1.0
4.00	1.0
4.02	−1.0
4.80	−1.0
4.82	1.0
5.20	1.0

(cont.)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
5.22	−1.0
6.00	−1.0
6.02	0.0
6.40	0.0
6.42	1.0
6.80	1.0
6.82	0.0
7.60	0.0
7.62	−1.0
8.00	−1.0
8.02	1.0
8.80	1.0
8.82	−1.0
9.60	−1.0
9.62	1.0
10.40	1.0
10.42	−1.0
11.20	−1.0
11.22	1.0
11.60	1.0
11.62	0.0
12.00	0.0

45 α OPTIMAL LONGITUDINAL STICK MANEUVER

Initial Conditions

$\alpha_o = 45°$

V_o = 156 knots h_o = 25,000 feet

$|\text{OBES } \eta_e|_{max}$ = 1.0 inch

Table 4

(Figure 4)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
0.00	0.0
0.02	−1.0
0.40	−1.0
0.42	0.0
0.80	0.0
0.82	1.0
1.20	1.0
1.22	−1.0
2.00	−1.0
2.02	0.0
2.80	0.0
2.82	−1.0
3.20	−1.0
3.22	1.0
4.00	1.0
4.02	−1.0
4.80	−1.0
4.82	1.0
5.60	1.0
5.62	0.0
6.00	0.0
6.02	−1.0

(cont.)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
6.40	−1.0
6.42	0.0
6.80	0.0
6.82	1.0
7.60	1.0
7.62	−1.0
8.40	−1.0
8.42	1.0
9.20	1.0
9.22	−1.0
9.60	−1.0
9.62	1.0
10.00	1.0
10.02	−1.0
10.80	−1.0
10.82	1.0
11.60	1.0
11.62	0.0
12.00	0.0

60 α OPTIMAL LONGITUDINAL STICK MANEUVER

Initial Conditions

$\alpha_o = 60°$

V_o = 163 knots h_o = 25,000 feet

$|\text{OBES } \eta_e|_{max}$ = 1.0 inch

Table 5

(Figure 5)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
0.00	0.0
0.02	–1.0
0.40	–1.0
0.42	0.0
0.80	0.0
0.82	–1.0
1.20	–1.0
1.22	1.0
2.00	1.0
2.02	–1.0
2.40	–1.0
2.42	1.0
3.20	1.0
3.22	0.0
3.60	0.0
3.62	1.0
4.00	1.0
4.02	0.0
4.40	0.0
4.42	–1.0
4.80	–1.0
4.82	1.0

(cont.)

OBES longitudinal stick

Time (seconds)	OBES η_e (inches)
5.60	1.0
5.62	0.0
6.00	0.0
6.02	–1.0
6.40	–1.0
6.42	0.0
7.20	0.0
7.22	–1.0
7.60	–1.0
7.62	1.0
8.40	1.0
8.42	–1.0
9.20	–1.0
9.22	0.0
9.60	0.0
9.62	1.0
10.40	1.0
10.42	–1.0
11.20	–1.0
11.22	0.0
12.00	0.0

LATERAL CLOSED LOOP OPTIMAL INPUT MANEUVERS

F-18 HARV using the NASA 1A Control Law

5 α OPTIMAL RUDDER PEDAL / LATERAL STICK MANEUVER

Initial Conditions

$\alpha_o = 5°$

$V_o = 370$ knots $h_o = 25{,}000$ feet

$|\text{OBES } \eta_r|_{max} = 100.0$ pounds $|\text{OBES } \eta_a|_{max} = 1.5$ inches

Table 6

(Figure 6)

OBES rudder pedal

Time (seconds)	OBES η_r (pounds)
0.00	0.0
0.02	100.0
0.50	100.0
0.52	0.0
1.00	0.0
1.02	100.0
1.50	100.0
1.52	−100.0
2.50	−100.0
2.52	100.0
3.00	100.0
3.02	−100.0
4.00	−100.0
4.02	100.0
5.00	100.0
5.02	−100.0
6.00	−100.0
6.02	0.0
6.50	0.0
6.52	100.0
7.00	100.0
7.02	0.0
7.50	0.0
7.52	100.0
8.00	100.0
8.02	0.0
16.00	0.0

OBES lateral stick

Time (seconds)	OBES η_a (inches)
0.00	0.0
9.00	0.0
9.02	1.5
9.50	1.5
9.52	−1.5
10.50	−1.5
10.52	1.5
11.50	1.5
11.52	−1.5
12.50	−1.5
12.52	1.5
13.00	1.5
13.02	0.0
13.50	0.0
13.52	−1.5
14.00	−1.5
14.02	1.5
15.00	1.5
15.02	−1.5
15.50	−1.5
15.52	0.0
16.00	0.0

20 α OPTIMAL RUDDER PEDAL / LATERAL STICK MANEUVER

Initial Conditions

$\alpha_o = 20°$

V_o = 198 knots h_o = 25,000 feet

| OBES η_r $|_{max}$ = 100.0 pounds | OBES η_a $|_{max}$ = 1.5 inches

Table 7

(Figure 7)

OBES rudder pedal

Time (seconds)	OBES η_r (pounds)
0.00	0.0
0.02	100.0
0.50	100.0
0.52	0.0
1.00	0.0
1.02	100.0
1.50	100.0
1.52	–100.0
2.50	–100.0
2.52	100.0
3.00	100.0
3.02	–100.0
4.00	–100.0
4.02	0.0
4.50	0.0
4.52	100.0
5.00	100.0
5.02	–100.0
6.00	–100.0
6.02	100.0
7.00	100.0
7.02	0.0
7.50	0.0
7.52	100.0
8.00	100.0
8.02	0.0
16.00	0.0

OBES lateral stick

Time (seconds)	OBES η_a (inches)
0.00	0.0
9.00	0.0
9.02	–1.5
9.50	–1.5
9.52	1.5
11.50	1.5
11.52	–1.5
14.00	–1.5
14.02	1.5
15.50	1.5
15.52	0.0
16.00	0.0

30 α OPTIMAL RUDDER PEDAL / LATERAL STICK MANEUVER

Initial Conditions

$\alpha_o = 30°$

$V_o = 167$ knots $\quad h_o = 25{,}000$ feet

$|\text{OBES } \eta_r|_{max} = 100.0$ pounds $\quad |\text{OBES } \eta_a|_{max} = 1.5$ inches

Table 8

(Figure 8)

OBES rudder pedal

Time (seconds)	OBES η_r (pounds)
0.00	0.0
0.02	100.0
1.00	100.0
1.02	0.0
1.50	0.0
1.52	−100.0
2.00	−100.0
2.02	100.0
3.00	100.0
3.02	0.0
4.00	0.0
4.02	−100.0
5.00	−100.0
5.02	0.0
5.50	0.0
5.52	100.0
7.00	100.0
7.02	0.0
16.00	0.0

OBES lateral stick

Time (seconds)	OBES η_a (inches)
0.00	0.0
8.00	0.0
8.02	1.5
9.50	1.5
9.52	−1.5
12.50	−1.5
12.52	0.0
13.00	0.0
13.02	1.5
15.50	1.5
15.52	0.0
16.00	0.0

45 α OPTIMAL RUDDER PEDAL / LATERAL STICK MANEUVER

Initial Conditions

$\alpha_o = 45°$

V_o = 156 knots h_o = 25,000 feet

$|\text{OBES } \eta_r|_{max}$ = 100.0 pounds $|\text{OBES } \eta_a|_{max}$ = 1.5 inches

Table 9

(Figure 9)

OBES rudder pedal

Time (seconds)	OBES η_r (pounds)
0.00	0.0
0.02	100.0
1.00	100.0
1.02	0.0
1.50	0.0
1.52	100.0
2.00	100.0
2.02	0.0
2.50	0.0
2.52	100.0
3.50	100.0
3.52	–100.0
4.50	–100.0
4.52	0.0
5.00	0.0
5.02	100.0
6.00	100.0
6.02	0.0
6.50	0.0
6.52	–100.0
7.00	–100.0
7.02	0.0
16.00	0.0

OBES lateral stick

Time (seconds)	OBES η_a (inches)
0.00	0.0
8.00	0.0
8.02	1.5
10.00	1.5
10.02	–1.5
12.50	–1.5
12.52	1.5
13.50	1.5
13.52	–1.5
15.50	–1.5
15.52	0.0
16.00	0.0

60 α OPTIMAL RUDDER PEDAL / LATERAL STICK MANEUVER

Initial Conditions

$\alpha_o = 60°$

V_o = 163 knots h_o = 25,000 feet

$|\text{OBES } \eta_r|_{max}$ = 100.0 pounds $|\text{OBES } \eta_a|_{max}$ = 1.5 inches

Table 10

(Figure 10)

OBES rudder pedal

Time (seconds)	OBES η_r (pounds)
0.00	0.0
0.02	–100.0
1.00	–100.0
1.02	0.0
1.50	0.0
1.52	–100.0
2.00	–100.0
2.02	100.0
2.50	100.0
2.52	–100.0
3.50	–100.0
3.52	100.0
5.00	100.0
5.02	–100.0
6.00	–100.0
6.02	0.0
6.50	0.0
6.52	100.0
7.00	100.0
7.02	0.0
16.00	0.0

OBES lateral stick

Time (seconds)	OBES η_a (inches)
0.00	0.0
8.00	0.0
8.02	1.5
11.00	1.5
11.02	–1.5
12.00	–1.5
12.02	0.0
12.50	0.0
12.52	1.5
14.00	1.5
14.02	–1.5
15.50	–1.5
15.52	0.0
16.00	0.0

VI. Control Time Histories

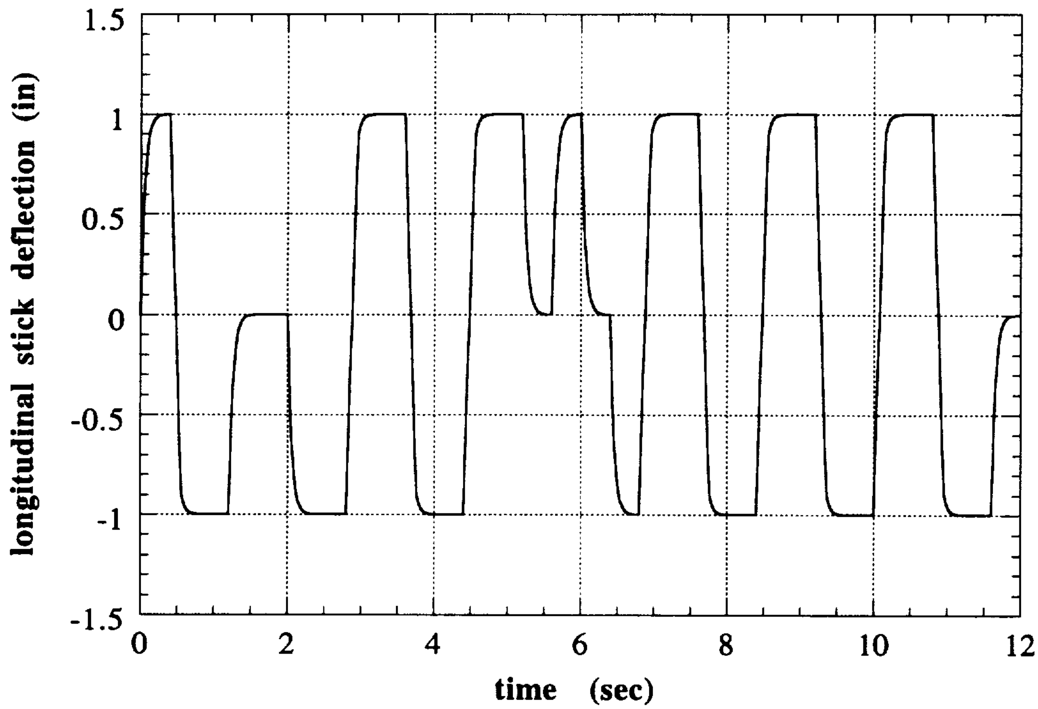

Figure 1 F-18 HARV Optimal Longitudinal Stick Input, $\alpha = 5$ degrees

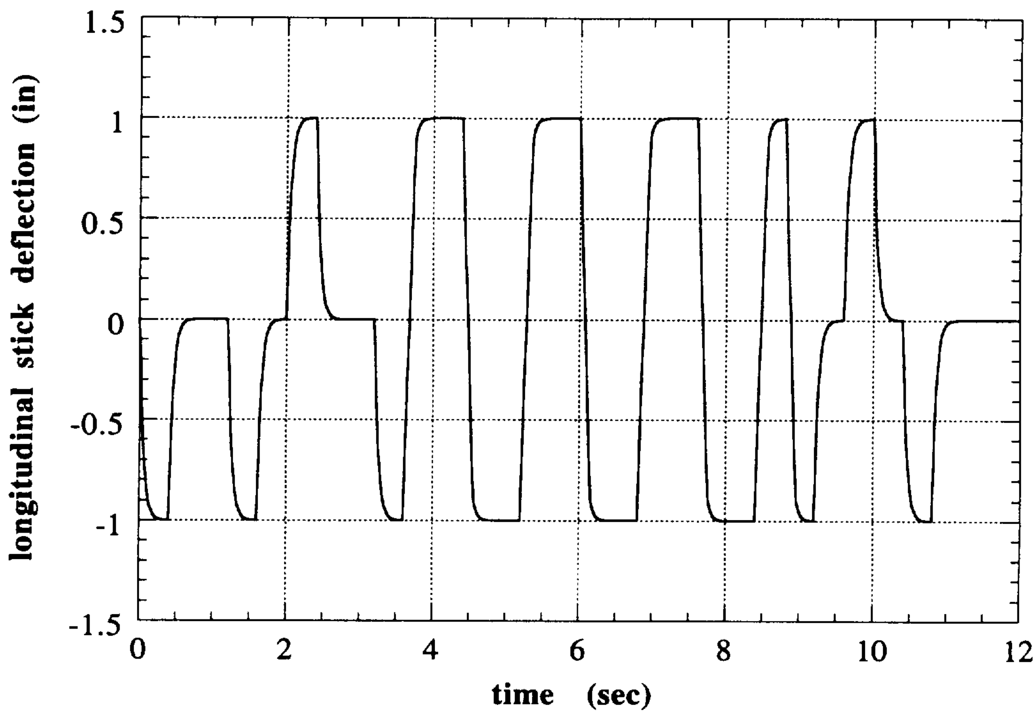

Figure 2 F-18 HARV Optimal Longitudinal Stick Input, $\alpha = 20$ degrees

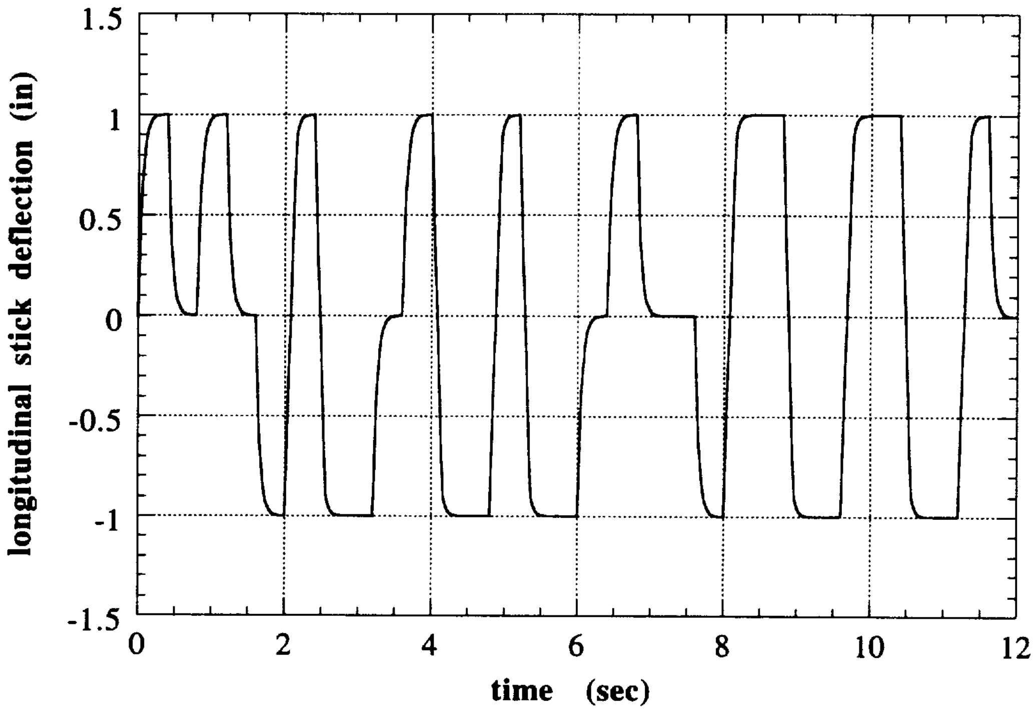

Figure 3 F-18 HARV Optimal Longitudinal Stick Input, $\alpha = 30$ degrees

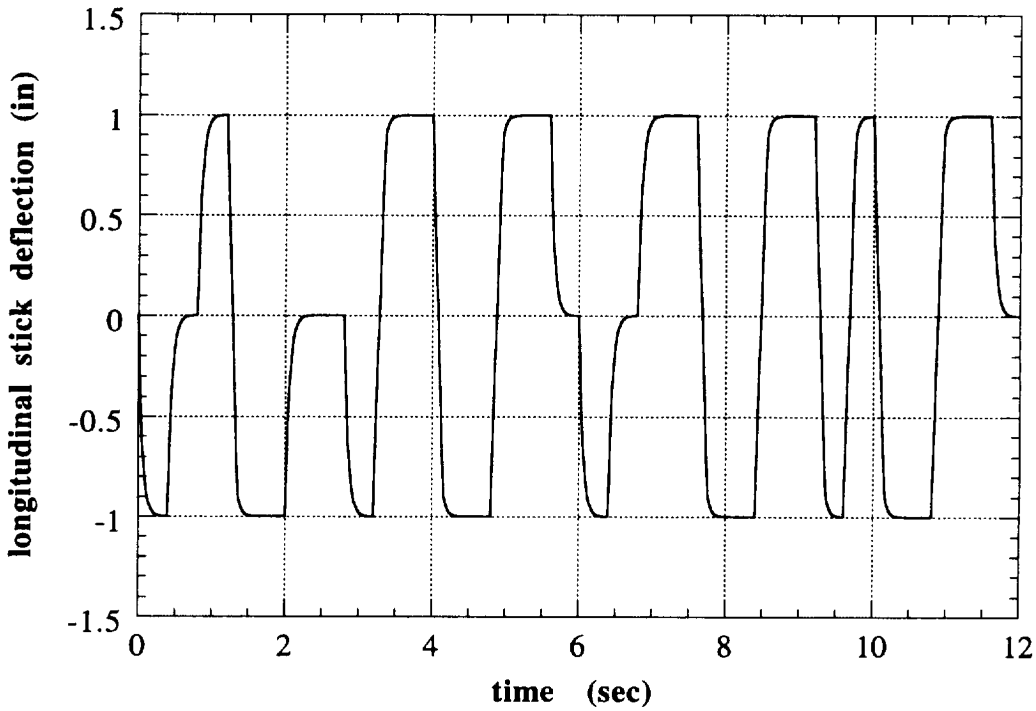

Figure 4 F-18 HARV Optimal Longitudinal Stick Input, $\alpha = 45$ degrees

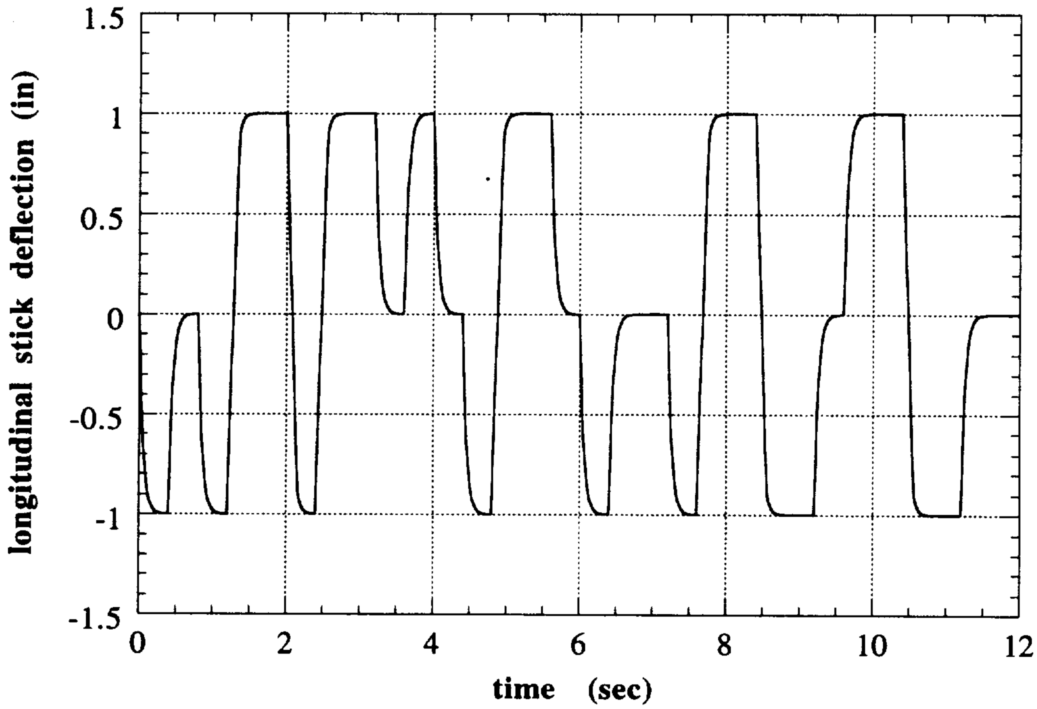

Figure 5 F-18 HARV Optimal Longitudinal Stick Input, $\alpha = 60$ degrees

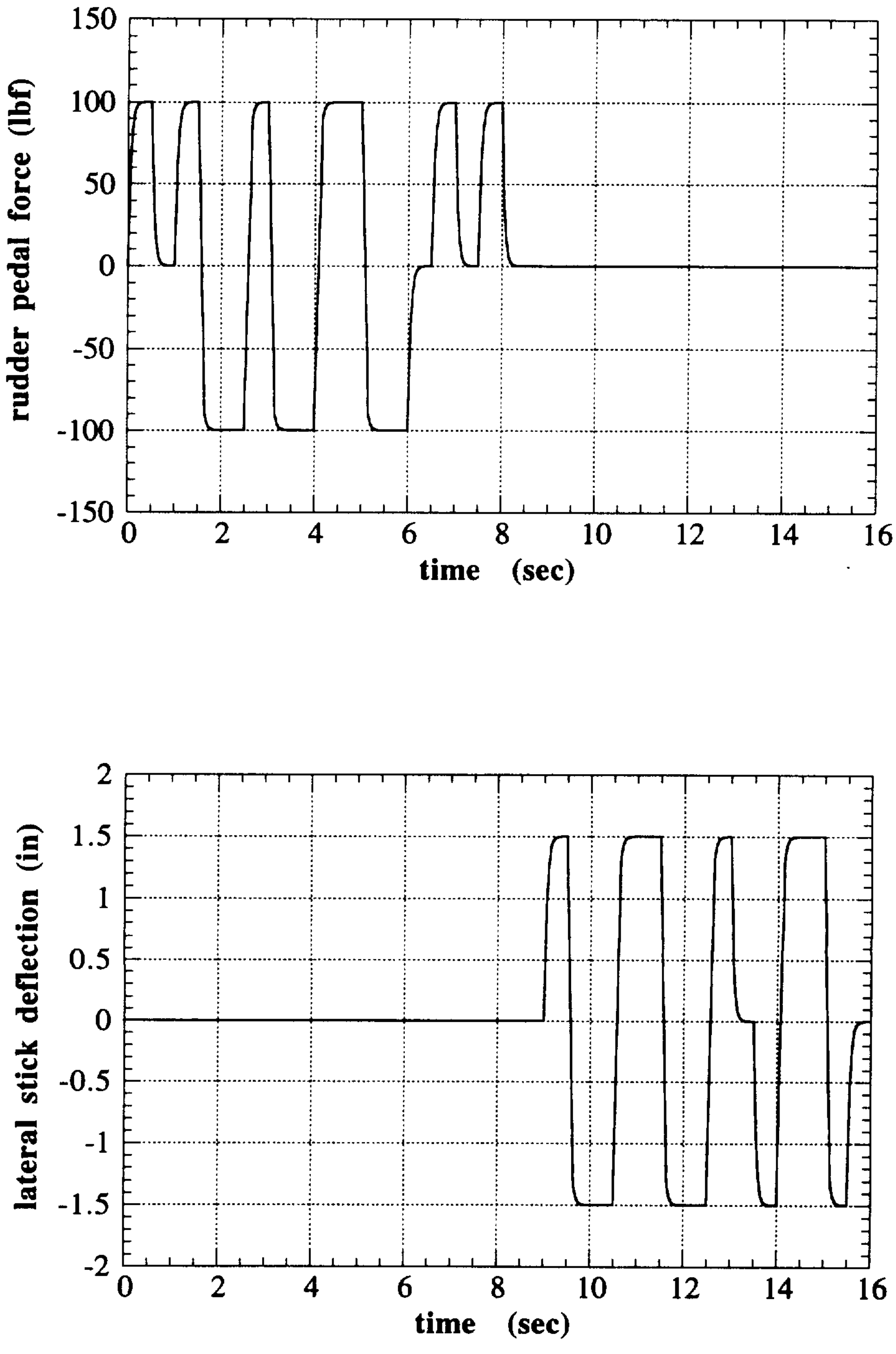

Figure 6 F-18 HARV Optimal Rudder Pedal and Lateral Stick Inputs, $\alpha = 5$ degrees

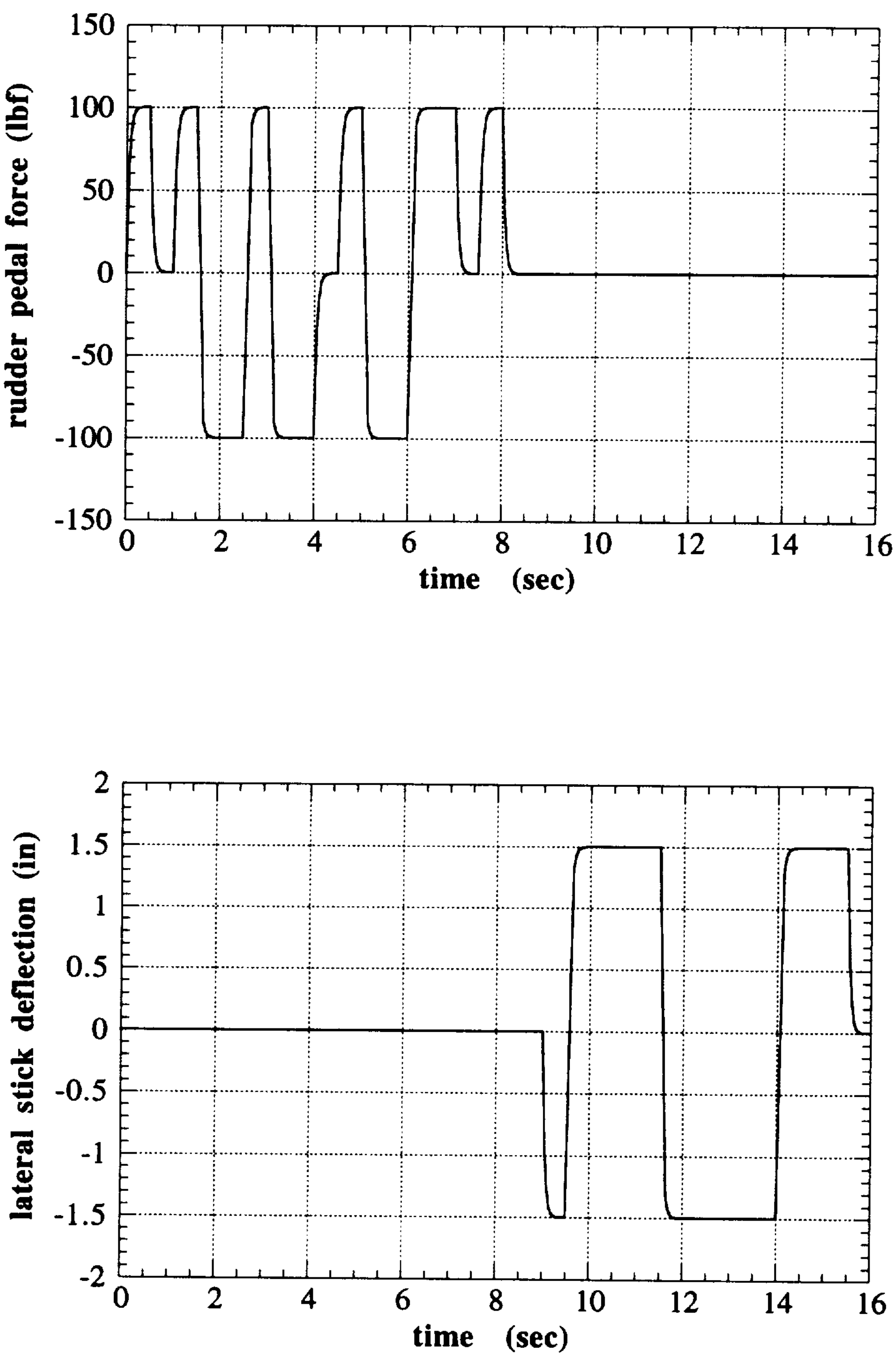

Figure 7 F-18 HARV Optimal Rudder Pedal and Lateral Stick Inputs, $\alpha = 20$ degrees

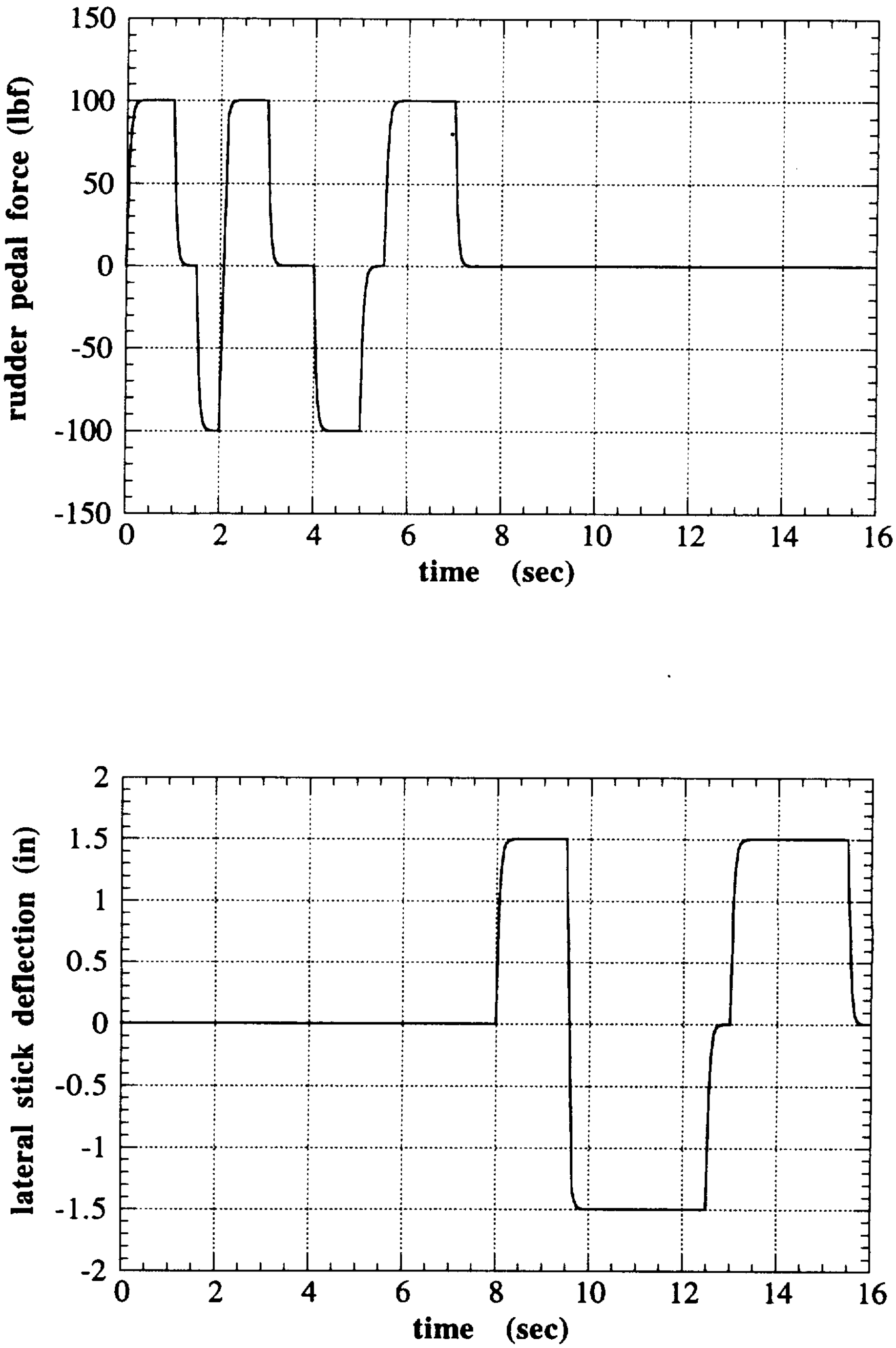

Figure 8 F-18 HARV Optimal Rudder Pedal and Lateral Stick Inputs, $\alpha = 30$ degrees

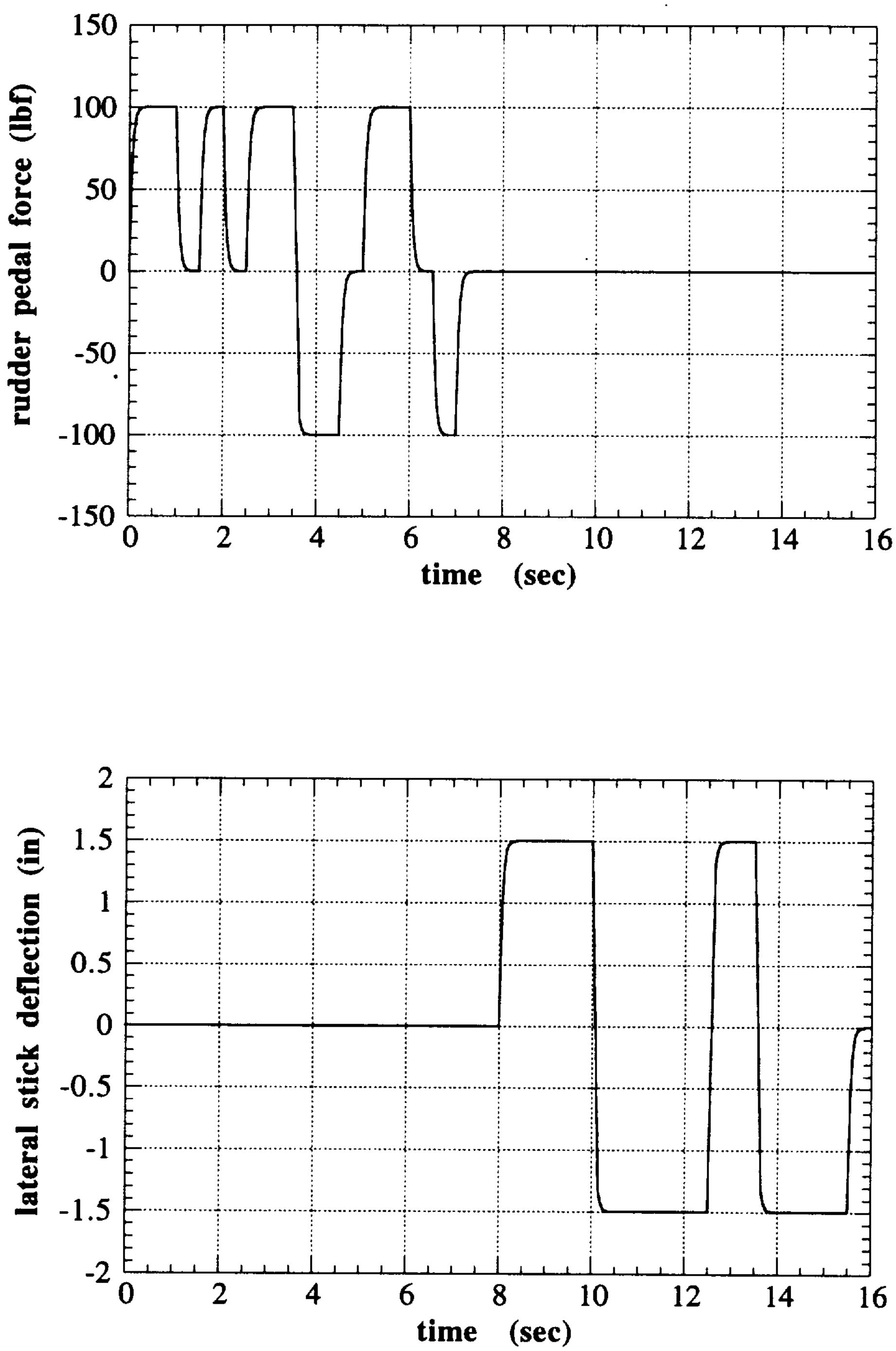

Figure 9 F-18 HARV Optimal Rudder Pedal and Lateral Stick Inputs, $\alpha = 45$ degrees

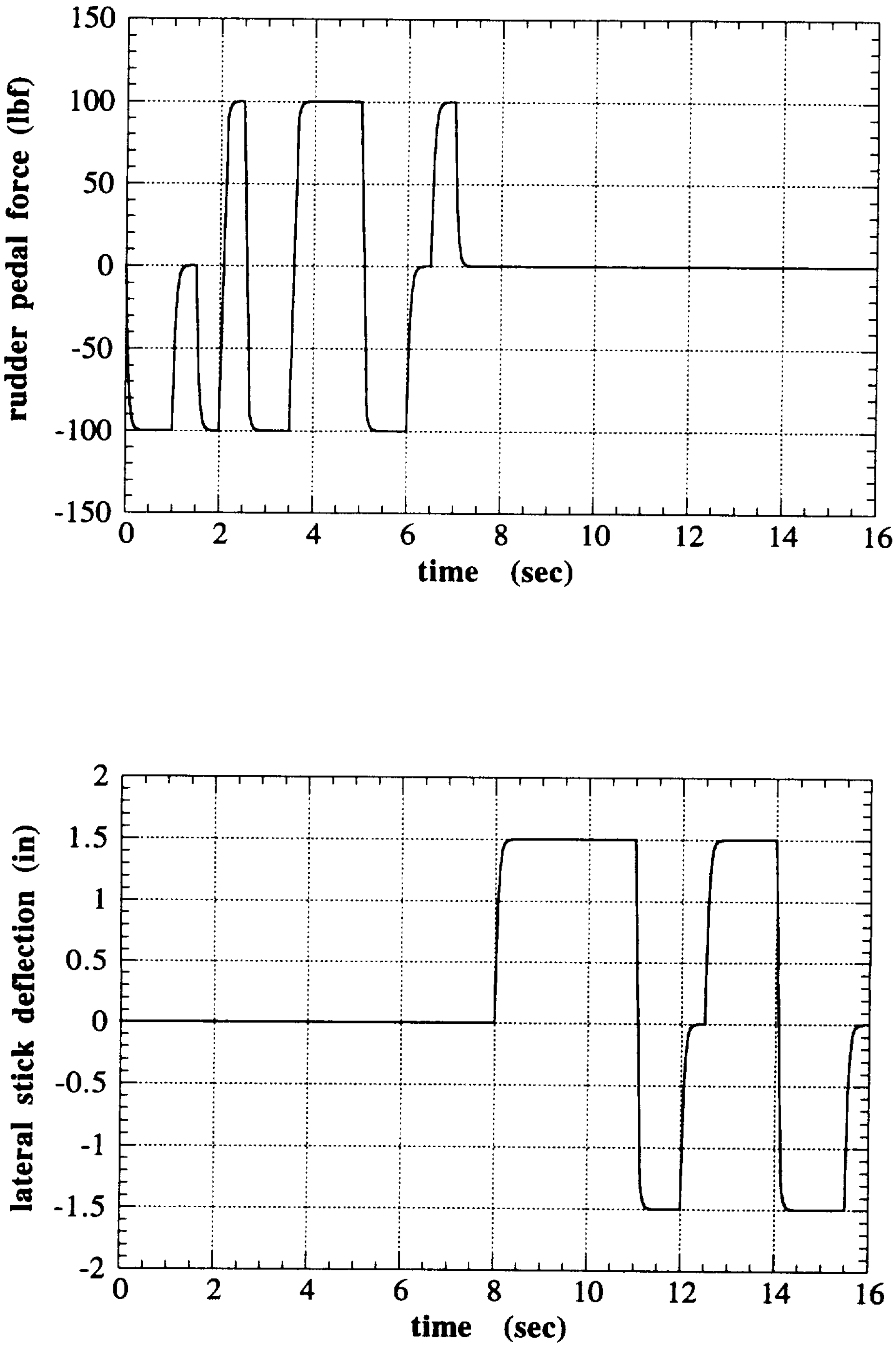

Figure 10 F-18 HARV Optimal Rudder Pedal and Lateral Stick Inputs, $\alpha = 60$ degrees

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 1996	Contractor Report

4. TITLE AND SUBTITLE
Piloted Parameter Identification Flight Test Maneuvers for Closed Loop Modeling of the F-18 High Alpha Research Vehicle (HARV)

5. FUNDING NUMBERS
C NAS1-19000

WU 505-64-52-01

6. AUTHOR(S)
Eugene A. Morelli

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Lockheed Martin Engineering & Sciences Co.
Langley Program Office
144 Research Drive
Hampton, VA 23666

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Langley Research Center
Hampton, VA 23681-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
NASA CR-198268

11. SUPPLEMENTARY NOTES
Langley Technical Monitor: James G. Batterson

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified Unlimited

Subject Category - 05

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

Flight test maneuvers are specified for the F-18 High Alpha Research Vehicle (HARV). The maneuvers were designed for closed loop parameter identification purposes, specifically for longitudinal and lateral linear model parameter estimation at 5, 20, 30, 45, and 60 degrees angle of attack, using the NASA 1A control law. Each maneuvers is to be realized by the pilot applying square wave inputs to specific pilot station controls. Maneuver descriptions and complete specifications of the time/amplitude points defining each input are included, along with plots of the input time histories.

14. SUBJECT TERMS
Flight test maneuvers, parameter identification, optimal input design, closed loop modeling, pilot implementation, F-18 HARV

15. NUMBER OF PAGES
31

16. PRICE CODE
A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		